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(54) **ACOUSTIC SOURCES FOR AIR DATA SYSTEMS**

AKUSTISCHE QUELLEN FÜR LUFTDATENSYSTEME

SOURCES ACOUSTIQUES POUR SYSTÈMES DE DONNÉES D'AIR

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Description

BACKGROUND

1. Field

[0001] The present disclosure relates to air data systems, more specifically to acoustic sources for air data systems, e.g., ultrasonic air data systems (UADS).

2. Description of Related Art

[0002] Certain SASAR (Sound Amplification through the Synchronous Accumulation of Radiation) acoustic sources create high amplitude acoustic vibrations using a combination of a resonating stack and a metamaterial gate, but are directional sources. Ultrasonic air data systems can utilize an acoustic signal to measure freestream velocity, flow angle, and speed of sound, for example, using the transmission time between an acoustic source(s) and acoustic receivers. Existing acoustic sources provide limited amplitude and directivity. Further, high frequencies attenuate quickly in air (and there's a large acoustic impedance mismatch to air), and in certain applications there is a high background noise environment, e.g., at high aircraft speeds. In view of the above, there is still a need in the art for acoustic sources for air data systems. The present disclosure provides a solution for this need. US 3,548,653 describes a direction and velocity determining apparatus.

SUMMARY

[0003] According to a first aspect, an ultrasonic air data system (UADS) system is provided according to claim 1 The SASAR acoustic source can include a generator configured to generate the acoustic signal, and a gate configured to selectively pass the acoustic signal.

[0004] The acoustic signal shaping feature can include a waveguide recessed from an outermost surface of the body. The waveguide can include any suitable shape (e.g., a bowl or speaker shape).

[0005] In certain embodiments, the acoustic signal shaping feature can include a horn operatively connected to the acoustic source. The horn can be disposed in the waveguide such that it does not protrude past the outer most surface of the body. Any other suitable configuration is contemplated herein.

[0006] The one or more acoustic receivers can be disposed in the body at the outermost surface of the body. Any other suitable location for the acoustic receivers is contemplated herein.

[0007] According to a second aspect, a method is provided according to claim 7. The method includes emitting the directional acoustic signal.

[0008] In certain embodiments, emitting the directional acoustic signal can include emitting a pulse from the SASAR acoustic source (e.g., for time of flight measurement). In certain embodiments, emitting the directional acoustic signal can include emitting a constant acoustic signal (e.g., for phase measurement of signal).

[0009] The method can include receiving the reshaped acoustic signal at one or more acoustic receivers. The method can include determining air data based on a time-of-flight of the reshaped signal between the acoustic source and the one or more acoustic receivers.

[0010] According to the invention, an ultrasonic air data system includes a SASAR acoustic source configured to output an acoustic signal, and one or more acoustic receivers configured to receive the acoustic signal.

[0011] These and other features of the systems and methods of the subject disclosure will become more readily apparent to those skilled in the art from the following detailed description taken in conjunction with the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] So that those skilled in the art to which the subject disclosure appertains will readily understand how to make and use the devices and methods of the subject disclosure without undue experimentation, embodiments thereof will be described in detail herein below with reference to certain figures, wherein:

Fig. 1 is a schematic diagram of an embodiment of a system in accordance with this disclosure.

DETAILED DESCRIPTION

[0013] Reference will now be made to the drawings wherein like reference numerals identify similar structural features or aspects of the subject disclosure. For purposes of explanation and illustration, and not limitation, an illustrative view of an embodiment of a system in accordance with the disclosure is shown in Fig. 1 and is designated generally by reference character 100. The systems and methods described herein can be used to, e.g., provide high amplitude acoustic signals to receivers of an air data system.

[0014] Referring to Fig. 1, an ultrasonic air data system (UADS) 100 includes a body 101 configured to mount to an aircraft (not shown). The system 100 includes an acoustic signal shaping feature 103 associated with (e.g., defined in and/or attached to) the body 101.

[0015] An acoustic source 105 is operatively connected to the acoustic signal shaping feature 103. The acoustic source 105 is configured to emit a directional acoustic signal. The acoustic signal shaping feature 103 is configured to reshape the directional acoustic signal from the acoustic source 105 into an at least partially reshaped signal (e.g., a hemisphere, a partial toroid, a cone, square, etc.). In certain embodiments, the feature 103 can be configured to optimally reshape the direction acoustic signal for improved functionality of the UADS 100. The optimal shape can be determined by one having ordinary skill in the art without undue experimentation.

Any suitable reshaping is contemplated herein.

[0016] As shown, the acoustic source 105 is a SASAR acoustic source. For example, the acoustic source 105 can include a generator 105a (e.g., comprising a piezoelectric stack that can build/resonate a high amplitude signal) configured to generate the acoustic signal, and a gate 105b configured to selectively pass the acoustic signal (e.g., in pulses after build up of, e.g., about 10 milliseconds to about 25 milliseconds). The SASAR acoustic source can include any suitable design, e.g., as appreciated by those having ordinary skill in the art, and any suitable controller/energy source (e.g., having any suitable hardware and/or software) to control the SASAR source.

[0017] The acoustic signal shaping feature 103 can include a waveguide 109 recessed from an outermost surface 101a of the body 101. The waveguide 109 can be or include any suitable shape (e.g., a bowl or speaker shape as shown).

[0018] In certain embodiments, the acoustic signal shaping feature 103 can be or include a horn 111 operatively connected to the acoustic source 105. The horn 111 can be disposed in the waveguide 109 such that it does not protrude past the outer most surface 101a of the body 101. The horn 111 can be connected to the gate 105b of the acoustic source 105 to receive the acoustic signal and at least partially reshape the acoustic signal (e.g., through resonation of the horn 111).

[0019] The horn 111 can include any suitable shape (e.g., a dome shape having a solid resonant body and/or having one or more channels) as appreciated by those having ordinary skill in the art in view of this disclosure. Any other suitable configuration is contemplated herein.

[0020] The horn 111 and/or waveguide 109 can be designed to match the impedance of air. Any other configuration is contemplated herein.

[0021] The system 100 can include one or more acoustic receivers 107 disposed on or at least partially within the body 101 for receiving the at least partially reshaped signal. As shown, the one or more acoustic receivers 107 can be disposed in the body 101 at the outermost surface of the body. Any other suitable location for the acoustic receivers 107 is contemplated herein.

[0022] A method includes shaping a directional acoustic signal emitted by an acoustic source (e.g., 105) of an air data system (e.g., 100) to be a reshaped acoustic signal (e.g., hemispherical or any other suitable shape). The method includes emitting the directional acoustic signal. According to the invention, the acoustic source 105 is a SASAR acoustic source (e.g., which vibrates vertically and produces a vertically directed acoustic signal pulse).

[0023] In certain embodiments, emitting the directional acoustic signal can include emitting a pulse from the SASAR acoustic source (e.g., for time of flight measurement). In certain embodiments, emitting the directional acoustic signal can include emitting a constant acoustic signal (e.g., for signal phase measurement).

[0024] The method can include receiving the reshaped acoustic signal at one or more acoustic receivers. The method can include determining air data based on a time-of-flight of the reshaped signal between the acoustic source and the one or more acoustic receivers.

[0025] According to the invention, an ultrasonic air data system includes a SASAR acoustic source configured to output an acoustic signal, and one or more acoustic receivers configured to receive the acoustic signal.

[0026] The use of a directional, e.g., SASAR type, acoustic source in conjunction with an ultrasonic air data system is a unique technical combination. Embodiments can include one more sources combined with one or more acoustic receivers to measure the propagation time through the local flow field in the boundary layer on an aircraft. Embodiments can provide a loud source not traditionally available. Existing sources are not sufficiently powerful to produce a reliable signal to noise ratio.

[0027] Certain embodiments can provide higher amplitude ultrasonic source than currently available, pulse shaping of the acoustic wave, coupling with an acoustic horn that propagates the sound in a spherical or other optimal pattern, and use of multiple frequencies of SASAR stack resonance to allow for better air data for determining flow characteristics. Existing acoustic sources provide limited amplitude and directivity. A more powerful source like SASAR can be used for such an application to provide a stronger Signal to Noise Ratio.

[0028] Those having ordinary skill in the art understand that any numerical values disclosed herein can be exact values or can be values within a range. Further, any terms of approximation (e.g., "about", "approximately", "around") used in this disclosure can mean the stated value within a range. For example, in certain embodiments, the range can be within (plus or minus) 20%, or within 10%, or within 5%, or within 2%, or within any other suitable percentage or number as appreciated by those having ordinary skill in the art (e.g., for known tolerance limits or error ranges).

[0029] The embodiments of the present disclosure, as described above and shown in the drawings, provide for improvement in the art to which they pertain.

Claims

1. An ultrasonic air data system (100), comprising:

   a body (101) configured to mount to an aircraft;
   an acoustic signal shaping feature (103) associated with the body (101);
   a Sound Amplification through Synchronous Accumulation of Radiation "SASAR" acoustic source (105) operatively connected to the acoustic signal shaping feature (103), the acoustic source (105) configured to emit a directional acoustic signal, wherein the acoustic signal shaping feature (103) is configured to re-

shape the directional acoustic signal from the acoustic source (105) into an at least partially reshaped signal; and
one or more acoustic receivers (107) disposed on or at least partially within the body for receiving the reshaped signal.

2. The system of claim 1, wherein the SASAR acoustic source (105) includes a generator configured to generate the acoustic signal, and a gate configured to selectively pass the acoustic signal.

3. The system of claim 1, wherein the acoustic signal shaping feature (103) includes a waveguide recessed from an outermost surface of the body (101).

4. The system of claim 3, wherein the acoustic signal shaping feature(103) includes a horn operatively connected to the acoustic source (105).

5. The system of claim 4, wherein the horn (111) is disposed in the waveguide such that it does not protrude past the outer most surface of the body (101).

6. The system of claim 1, wherein the one or more acoustic receivers (107) are disposed in the body at the outermost surface of the body (101).

7. A method, comprising:
shaping a directional acoustic signal emitted by a Sound Amplification through Synchronous Accumulation of Radiation "SASAR" acoustic source (105) of an air data system to be a reshaped acoustic signal.

8. The method of claim 7, further comprising emitting the directional acoustic signal.

9. The method of claim 7, wherein emitting the directional acoustic signal includes emitting a pulse from the SASAR acoustic source (105).

10. The method of claim 9, wherein emitting the directional acoustic signal includes emitting a constant acoustic signal.

11. The method of claim 10, further comprising receiving the reshaped acoustic signal at one or more acoustic receivers (107).

12. The method of claim 11, further comprising determining air data based on a time-of-flight of the reshaped signal between the acoustic source (105) and the one or more acoustic receivers (107).

Patentansprüche

1. Ultraschall-Luftdatensystem (100), umfassend:

einen Körper (101), der dazu konfiguriert ist, an einem Luftfahrzeug montiert zu werden;
ein akustisches Signalformungsmerkmal (103), das dem Körper (101) zugeordnet ist;
eine akustische Quelle (105) zur Schallverstärkung durch synchrone Akkumulation von Strahlung (Sound Amplification through Synchronous Accumulation of Radiation, "SASAR"), die betriebsfähig mit dem akustischen Signalformungsmerkmal (103) verbunden ist, wobei die akustische Quelle (105) dazu konfiguriert ist, ein gerichtetes akustisches Signal auszusenden, wobei das akustische Signalformungsmerkmal (103) dazu konfiguriert ist, das gerichtete akustische Signal von der akustischen Quelle (105) in ein zumindest teilweise umgestaltetes Signal umzugestalten; und
einen oder mehrere akustische Empfänger (107), die auf oder zumindest teilweise innerhalb des Körpers angeordnet sind, um das umgestaltete Signal zu empfangen.

2. System nach Anspruch 1, wobei die akustische SASAR-Quelle (105) einen Generator beinhaltet, der dazu konfiguriert ist, das akustische Signal zu erzeugen, und ein Tor, das dazu konfiguriert ist, das akustische Signal selektiv durchzulassen.

3. System nach Anspruch 1, wobei das akustische Signalformungsmerkmal (103) einen Wellenleiter umfasst, der von einer äußersten Oberfläche des Körpers (101) ausgenommen ist.

4. System nach Anspruch 3, wobei das Signalformungsmerkmal (103) ein Horn umfasst, das betriebsfähig mit der akustischen Quelle (105) verbunden ist.

5. System nach Anspruch 4, wobei das Horn (111) im Wellenleiter so angeordnet ist, dass es nicht über die äußerste Oberfläche des Körpers (101) hinausragt.

6. System nach Anspruch 1, wobei der eine oder die mehreren akustischen Empfänger (107) in dem Körper an der äußersten Oberfläche des Körpers (101) angeordnet sind.

7. Verfahren, umfassend:
Formen eines gerichteten akustischen Signals, das von einer akustischen Quelle (105) eines Luftdatensystems zur Schallverstärkung durch synchrone Akkumulation von Strahlung "SASAR" ausgesendet wird, um ein umgestaltetes akustisches Signal zu

sein.

8. Verfahren nach Anspruch 7, ferner umfassend Aussenden des gerichteten akustischen Signals.

9. Verfahren nach Anspruch 7, wobei das Aussenden des gerichteten akustischen Signals das Aussenden eines Impulses von der akustischen SASAR-Quelle (105) beinhaltet.

10. Verfahren nach Anspruch 9, wobei das Aussenden des gerichteten akustischen Signals das Aussenden eines konstanten akustischen Signals beinhaltet.

11. Verfahren nach Anspruch 10, ferner umfassend Empfangen des umgestalteten akustischen Signals an einem oder mehreren akustischen Empfängern (107).

12. Verfahren nach Anspruch 11, ferner umfassend Bestimmen von Luftdaten basierend auf einer Flugdauer des umgestalteten Signals zwischen der akustischen Quelle (105) und dem einen oder mehreren akustischen Empfängern (107).

Revendications

1. Système de données d'air ultrasonore (100), comprenant :

   un corps (101) configuré pour être monté sur un avion ;
   un élément de mise en forme de signal acoustique (103) associé au corps (101) ;
   une source acoustique d'amplification sonore par accumulation synchrone de rayonnement « SASAR » (105) fonctionnellement connectée à l'élément de mise en forme de signal acoustique (103), la source acoustique (105) étant configurée pour émettre un signal acoustique directionnel, dans lequel l'élément de mise en forme de signal acoustique (103) est configuré pour remodeler le signal acoustique directionnel provenant de la source acoustique (105) en un signal au moins partiellement remodelé ; et
   un ou plusieurs récepteurs acoustiques (107) disposés sur le ou au moins partiellement à l'intérieur du corps pour recevoir le signal remodelé.

2. Système selon la revendication 1, dans lequel la source acoustique SASAR (105) comporte un générateur configuré pour générer le signal acoustique, et une porte configurée pour laisser passer sélectivement le signal acoustique.

3. Système selon la revendication 1, dans lequel l'élément de mise en forme de signal acoustique (103) comporte un guide d'ondes en retrait depuis une surface la plus externe du corps (101) .

4. Système selon la revendication 3, dans lequel l'élément de mise en forme de signal acoustique (103) comporte un pavillon connecté fonctionnellement à la source acoustique (105).

5. Système selon la revendication 4, dans lequel le pavillon (111) est disposé dans le guide d'ondes de telle sorte qu'il ne dépasse pas de la surface la plus externe du corps (101).

6. Système selon la revendication 1, dans lequel les un ou plusieurs récepteurs acoustiques (107) sont disposés dans le corps au niveau de la surface la plus externe du corps (101).

7. Procédé comprenant :
   la modélisation d'un signal acoustique directionnel émis par une source acoustique d'amplification sonore par accumulation synchrone de rayonnement « SASAR » (105) d'un système de données d'air pour en faire un signal acoustique remodelé.

8. Procédé selon la revendication 7, comprenant en outre l'émission du signal acoustique directionnel.

9. Procédé selon la revendication 7, dans lequel l'émission du signal acoustique directionnel comporte l'émission d'une impulsion à partir de la source acoustique SASAR (105).

10. Procédé selon la revendication 9, dans lequel l'émission du signal acoustique directionnel comporte l'émission d'un signal acoustique constant.

11. Procédé selon la revendication 10, comprenant en outre la réception du signal acoustique remodelé au niveau d'un ou plusieurs récepteurs acoustiques (107).

12. Procédé selon la revendication 11, comprenant en outre la détermination de données d'air sur la base d'un temps de vol du signal remodelé entre la source acoustique (105) et les un ou plusieurs récepteurs acoustiques (107).

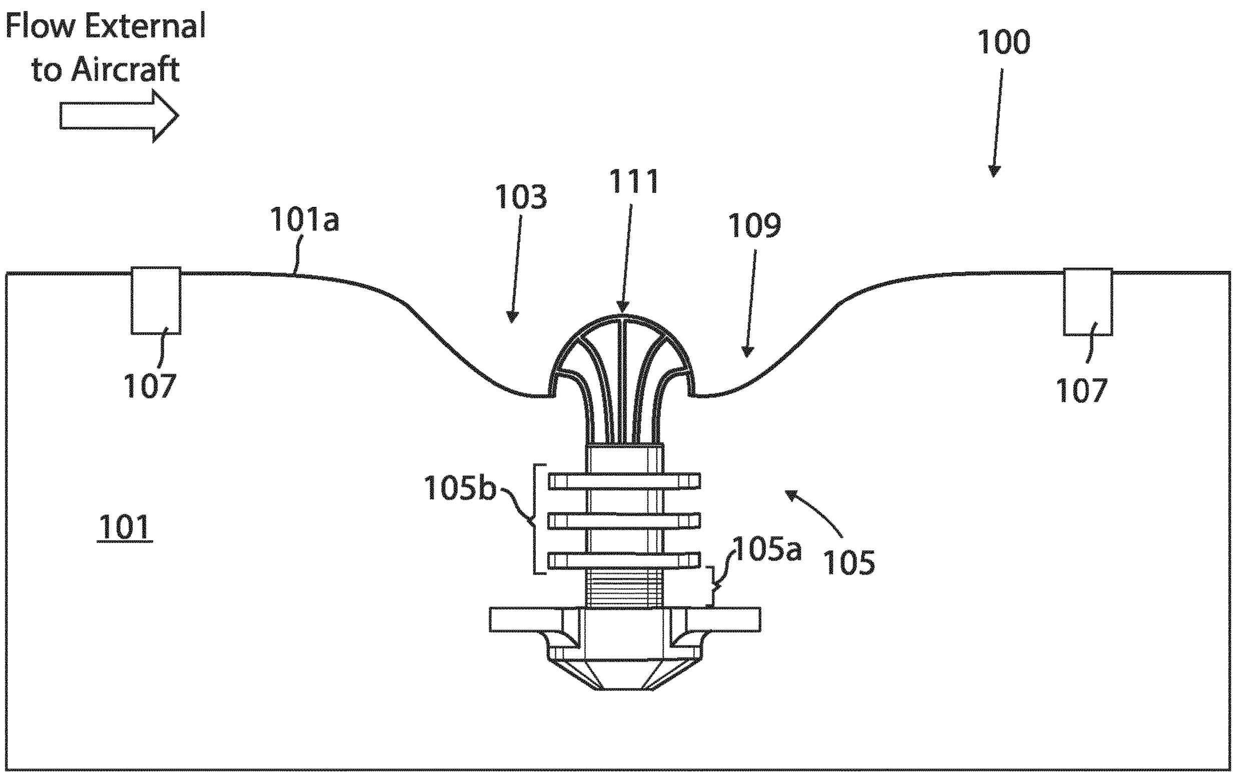
Flow External
to Aircraft
100
101a
103
111
109
107
107
105b
101
105a
105

Fig. 1

REFERENCES CITED IN THE DESCRIPTION

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